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By

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DEDICATION

To Amelia Earhart and all the women

who take to the sky

LOW BIRTH WEIGHT AND THE NATALITY EXPERIENCE OF FEMALE AVIATORS IN THE US AIR FORCE MILITARY AIRLIFT COMMAND AND STRATEGIC AIRLIFT COMMAND FROM JANUARY 1, 1980 TO DECMBER 31, 1994

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GILBERT R. HANSEN, B.A., M.D.

THESIS

Presented to the Faculty of the University of Texas

Health Science Center at Houston

School of Public Health

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF PUBLIC HEALTH

THE UNIVERISTY OF TEXAS HEALTH SCIENCE CENTER AT HOUSTON
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PREFACE

This work is original and based on data obtained from the Epidemiology Research Division of Armstrong Laboratory at Brooks Air Force Base, San Antonio, Texas in January of 1997. Further monitoring of natality statistics is vital to future efforts to quantify trends of pregnancy outcomes grouped by rare occupational exposures such as Air Force Aviation.

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THANK YOU

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LOW BIRTH WEIGHT AND THE NATALITY EXPERIENCE OF FEMALE AVIATORS IN THE US AIR FORCE MILITARY AIRLIFT COMMAND AND STRATEGIC AIRLIFT COMMAND FROM JANUARY 1, 1980 TO DECMBER 31, 1994

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Previous studies have demonstrated a two fold increase in term low birth weight newborns of active duty women as compared to age and race matched civilian counterparts delivering at the same military hospital by the same physicians. This observation raised the question, "is there a unique occupational exposure which might account for this observation or is the elevated risk experienced by all active duty women regardless of job assignment?"

An occupational exposure that is rather unique to the Air force is that of aviator. This thesis presents the demographics of the Natality experience of Air Force Aviators in Military Airlift Command and Strategic Airlift Command from 1980 to 1994 and compares the risk of Air Force aviators delivering term low birth weight infants to Air Force office workers at the same bases during the same time frames.

During the period of January 1, 1980 to December 31, 1994 there were 18,730 deliveries of live born infants to active duty women; of this number, 170 were deliveries of Air Force aviators. Only one of the 170 deliveries of aviators was a term low birth weight infant. Low birth weight was determined by selecting all infants having the International Classification of Diseases code of 764 "light for dates".

One case in 170 gave an incidence rate of 0.6% compared to 0.5% low birth weight infants in the 11,252 deliveries of office workers. There was no apparent departure of the aviator group from the comparison cohort, but due to the fact that there were so few aviator deliveries, the statistical power necessary to reject the alternative hypothesis: that there is a difference between aviators and officer workers, was not achieved.

The demographic experience of the 170 was then explored to ascertain if any other adverse pregnancy outcome presented to an unusually high degree. The most frequent adverse outcome was that of neonatal jaundice. This occurred in 13 of the 170 deliveries giving a risk of 7.6% compared to 11.8% in the comparison group. Other adverse outcomes were even less prevalent among aviators.

At this point in time the Natality experience of Air Force Aviators flying tankers and transports in Military Airlift Command and Strategic Airlift Command has not shown any unusual clustering of adverse neonatal outcomes. A larger number of deliveries with specific exposure data concerning flight hours, date of last menstrual period and infant birth weight will be needed to carry this study to a point where evidence will reach statistical reliability.

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INTRODUCTION

Previous studies have demonstrated an almost two fold increase in low birth weight newborns of active duty women as compared to age and race matched civilian comparisons (8.2% to 4.8%, RR = 1.7%) delivering at the same military hospital by the same physicians (Kruger, 1979; Magann, 1991). These observations raise the question, "is this a true or artifactual association?" If true, "is there a unique occupational exposure or cluster of exposures which might account for the associated risk of active duty women, or is the elevated risk experienced by all active duty women regardless of job assignment?"

An occupational exposure that is rather unique to the Air force is that of aviator. Aviators are exposed to decompression, hypoxia, vibration, unstable platform, higher levels of cosmic radiation, and the stress of working odd hours for prolonged lengths of time.

Concerning ionizing radiation, the body of evidence in the literature gives reason to believe that the minor doses of excess radiation experienced by aircrew members at 40,000 ft do not pose any likely structural health threats to the fetus, such as low birth weight, so long as the expectant crew member logs less than 50 hours per month in northern latitudes and less than 100 hours per month in southern latitudes (Friedberg, 1989).

There is one theoretical health risk. To date, there is no proven safety threshold for prenatal X-ray exposure below which a small excess risk of childhood leukemia has

been completely ruled out (BEIR V, 1990). Currently the maximum excess risk of childhood leukemia due to prenatal X-ray exposure is estimated at 1 in 2000 for each 10 miliSieverts of exposure during pregnancy (Metler, 1995). The occupational exposure limit is 5 miliSieverts for the entire pregnancy. At the maximum of the confidence interval (RR =1.4), 4000 fetuses exposed to 5 miliSieverts would run the possible risk of one excess case of leukemia. At the minimum of the confidence interval (RR = 0.8) the radiation would be protective.

Historically, hypoxia was a matter of concern for possible adverse effects on the fetus (Scholten, 1976). Normal cabin pressures are equivalent to 8000 feet of altitude. At this altitude the partial pressure of oxygen inhaled is reduced from 150 mm of Hg. to 110 mm of Hg. All tissues including the fetus would receive 25% less oxygen during flight. While early studies pointed in the direction of a true risk, refined studies did not demonstrate an association (Lyons, 1992).

Low birth weight has been associated with smoking (Walsh, 1994) and stress (Edwards, 1994). It is unknown how much these two factors contributed to the excess risk reported in the studies by Kruger and Magann.

With the knowledge that the radiation and hypoxia levels experienced by tanker and transport aircrew at altitudes of 40,000 feet should not contribute to excess low birth weight a study was proposed to test the null hypothesis: "when controlled for other known risks, there is no difference between the rate of low birth weight in the offspring

of Air Force tanker and transport aircrew than offspring of comparable Air Force active duty office workers.

Potential limitations of this study include: 1) unavailability of rates of smoking between the groups; 2) unavailability of the true birth weight necessitating a surrogate indicator to be designated; 3) small sample size of aviators.

Therefore, although the result of this study showed essentially no difference between the rates of aircrew and office workers, it must be born in mind that statistical power was lacking to reject the alternative hypothesis. Nevertheless, the descriptive studies of the natality experience of aircrew serving in Military Airlift Command and Strategic Airlift Command from 1980 to 1994 should prove useful in the continuing effort to define the limits of safety when it comes to flying.

Future studies will require accurate smoking histories, stress correlation, detailed flight logs, availability of last menstrual period, birth weight data, and a sample size of at least 5,000 aviators in order to put the question to rest once and for all. Attention will now turn to the background for this thesis.

BACKGROUND

This chapter is divided into six sections. Section one sets forth the definitions of low birth weight and associated diagnoses, Section two deals with the association between smoking and low birth weight. Section three summarizes the risks associated with stress during pregnancy.

Section four describes the current knowledge concerning exposure to ionizing radiation and low birth weight. Section five explores the facts concerning the effects of hypoxia on birth weight. Section six sets forth the design of the study proposed as part of this thesis. The results of the study are presented in the next chapter.

Other risk factors mentioned included vibration and unstable platform. These specific factors have not been studied directly in association with low birth weight.

SECTION 1: LOW BIRTH WEIGHT, DEFINITIONS

This section clarifies the definitions of low birth weight, very-low birth weight, small for gestational age, intra-uterine growth retardation, premature, and preterm delivery.

Low birth weight is defined as any newborn with a recorded birth weight of less than 2500 grams (Klauss, 1986). This classification is based entirely on the birth weight and has no reference to whether the newborn was carried to term, or delivered prematurely. A large number of exposures can result in an infant with low birth weight (Brooke 1989).

A fetus malnourished by an HIV positive mother who subsists mainly on alcohol, tobacco, and drugs born at 28 weeks gestation with a birth weight of 1502 grams clearly has a different prognosis than a fetus born at 34 weeks with a weight of 2400 grams to a healthy mother who ate a balanced diet, took prenatal vitamins, abstained from alcohol, tobacco, and drugs, but who had an incompetent cervix. Yet both are categorized as low birth weight infants.

The reason birth weight is studied so frequently is because it is a vital statistic entered almost universally on birth certificates. It is also an objective measurement not requiring the judgment of physicians or of clerical nosologists.

Because many problems of pregnancy show up as low birth weight it is useful as a screening tool as long as the effect from the cause being studied is as prevalent as the

other possible causes reflected in the study population which have not been controlled for. If related factors are not controlled for they may mask the effect being studied.

Because studies of low birth weight are non-specific as to effect, measures have been taken to find other more suitable categories to study specific effects on pregnancy. One effort is to subclassify the birth weights into low (1500-2499gms) and very low (less than 1500gms) birth weight. This certainly separated the extremely premature from the mildly premature infants, but this still did not solve the problem of dividing the specific effects.

To divide the truly premature from the mature but small infants diagnostic categories were devised. Preterm infant and premature infant are the same thing and are defined as an infant born prior to the 37th week of gestation.

Prematurity is reflected in the International Classification of Diseases (ICD) as code 765. This coding requires the physician to enter the diagnosis in the medical chart and for the clerical nosologist to accurately convert this into an ICD code and enter the code in the appropriate block. When working with a data base, this also requires the data entry technician to accurately type the ICD codes into the appropriate field.

Errors in this process would tend to under report premature deliveries. However, as long as populations being compared used the same hospitals at the same times, the error should tend to be reflected in both the population of interest and the comparison population to the same degree.

The classification of light for dates, sometimes referred to as small for gestational age, was created to label those infants who fall below the 10th percentile of the weight of all babies born at the same specific gestational age. Therefore an infant born at term weighing 2400 grams may be light for dates; whereas, an infant born at 32 weeks weighing 2400 grams may not be light for dates.

Another important concept is that an infant born light for dates may not be a cause for alarm. A 2400 gram infant born of a four foot ten inch, 96 pound, mom with a five foot, 105 pound, father and not showing any signs of distress or integumentary thinning may simply reflect a normal child below the 10th percentile of weight. Nevertheless, ICD code 764 is a code for all infants born below the 10th percentile of weight (ICD9).

Intrauterine growth retardation is a subset of light for dates in which fetal malnutrition is clinically obvious. This is a subclassification of light for dates and has been assigned the codes 764 decimal point followed by one through nine.

None of the classifications restrict the population to a single disease, and many causes may contribute to any one classification. It is of paramount importance when comparing one study group versus another to assure that the same criteria are used. When the same criteria are used, and confounding variables are controlled for, low birth weight or one of the other categories can be an important sentinel of deleterious exposure effects.

SECTION 2: LOW BIRTH WEIGHT AND SMOKING

Simpson first reported the association between cigarette smoking and low birth weight in 1957 (Simpson 1957). Since then hundreds of studies have been performed to try to refute or substantiate these claims (Lumley 1987). Throughout these studies there has been a remarkably consistent strength of association between offspring of smokers compared to nonsmokers. The accepted relative risk is 1.90 with a 95% confidence interval of 1.83 to1.98 (Walsh, 1994).

Brooke carried out a methodical study of over 40 risk factors associated with low birth weight and found that smoking by far was the single most important factor. Dose response studies using serum cotinine as a dose marker rather than self reporting, have shown a linear relationship between the amount of smoking and the corresponding reduction in birth weight (Li, 1993).

The US Department of Health and Human Services 1990 report demonstrated that infants of women who smoked weighed an average of 187 grams less than infants of nonsmokers (Walsh, 1994).

Biological plausibility studies have centered around nicotine, carbon monoxide, cyanide, and cadmium, all major constituents of cigarette smoke. Nicotine crosses the placental barrier and has been measured in amniotic fluid (Van Vunakis, 1974). Placental blood flow is reduced after smoking and nicotine is thought to cause this due to its vasoconstrictive effects (Benowitz, 1991).

Carbon monoxide from cigarette smoking decreases oxygen availability by 8% (Davies, 1979). Nonsmoking adults normally have less than 1 percent of their total circulating hemoglobin in the form of carboxyhemoglobin. Heavy smokers may show values as high as 5 to 10 percent (Klaassen, p344, 1996).

Cyanide is detoxified to thiocyanate in the fetal liver by Vitamin B12. Vitamin B12 is decreased in the infants of smokers (Gritz, 1980). Vitamin B12 is an important factor in growth and metabolism (Walsh, 1994).

Cadmium is known to cross the placenta (Chatterjee, 1988). Accumulation of cadmium in the placenta leads to morphological and functional impairment of the placenta (Sikorski, 1988).

There are few skeptics left, and the majority of scientists today involved in studies of smoking and reproduction are convinced that smoking imposes predictable deleterious effects upon the fetus (Walsh, 1994). The birth weight of infants born to smokers is predictably lowered by an average of 187 grams. This doubles the risk of having a baby born with low birth weight and its attendant problems.

SECTION 3: LOW BIRTH WEIGHT AND THE MILITARY CONNECTION

In 1979, Kruger extracted records of all the pregnancies carried beyond 20 weeks of active duty women delivered at Keesler AFB from 1974 to 1979 (Kruger, 1979). This amounted to 146 deliveries. He then selected from the larger pool of civilian delivering mothers, those who when matched for race had a delivery date closest to the date of delivery of the index case.

The results of this case comparison study showed active duty women suffered toxemia 1.6 times, low birth weight infants at 1.7 times, and small for gestational age at 2.93 times the rate of their civilian comparisons. The numbers in this study were too small for statistical significance, but the question was raised whether there truly was an association with active duty women and adverse pregnancy outcomes.

In 1991, Magann and Nolan again completed a case comparison study of active duty women compared to civilians (Magann, 1991). They compared 331 active duty deliveries with 1218 civilian controls matched for age and parity. The result of this study demonstrated a relative risk of 2.95 for active duty infants weighing less than 2500 grams compared to civilian controls. Possible mechanisms theorized included excessive work hours, lifting, standing and stress, (Saurel-Cubizolles 1985 Tafari 1980).

In civilian studies, excessive work hours have been correlated with low birth weight outcome (Mamelle, 1984). Excessive work load is probably not justifiable since active duty women are normally placed on a work restriction profile during their pregnancy.

Stress has also been implicated as a factor in low birth weight (Newton, 1984). Certainly this could play a role in many active duty personnel, but one is left to wonder if there is a unique occupational exposure in the Air Force which could account for this dramatic difference in birth weight.

One set of unique exposures occurs to Aviators. Aviators have higher than average exposures to ionizing radiation, and mild hypoxia.

The number of women working as crew members in aviation has been steadily growing. The largest group of women who fly is the airline stewardess.

Established policies and historical concern over the safety involved in frequent flying and fulfilling occupational duties of stewardesses while pregnant began to be challenged in the 1970s (Scholten, 1976). Airline stewardesses fought for and won the right to continue working during the first trimester. Most airlines today allow women to fly up to the 26th week. At that point they are grounded out of lack of fitness for duty rather than fetal protection.

The Air Force began allowing women to work as tanker and transport crew members in 1976. It was not until 1993 that women were allowed to fly in combat and high performance aircraft.

At altitude, aviators are exposed to higher levels of radiation and lower levels of oxygen than workers at ground level. In sections four and five the literature concerning these exposure factors and the current knowledge concerning any possible association with low birth weight will be explored.

SECTION 4: LOW BIRTH WEIGHT AND IONIZING RADIATION

Reports of adverse pregnancy outcomes due to intrauterine exposure to ionizing radiation began to emerge in the late 1920s (Goldstein, 1930). Goldstein reported several case series in which growth retardation, microcephally and mental retardation were noted among offspring of women receiving large doses of radiation in an attempt to cure various maladies.

Following the bombing of Hiroshima and Nagasaki, heroic efforts were made to catalog the effects of the bombings, including the incidence of adverse effects on newborns exposed to radiation in-utero (Yamasaki, 1954). Women exposed to high doses of ionizing radiation had infants that were growth retarded, microcephalic, and mentally retarded. These observations and the additional observation by Stewart in 1956 that childhood leukemia is linked to fetal exposures of ionizing radiation fueled a world wide effort to elucidate what might be considered a safe dose of radiation for expectant mothers (Stewart, 1956; MacMahon, 1962; Brown, 1967; Dekaben, 1968; Kirsten, 1968; Jablon, 1970; Diamond, 1973; Mole, 1974; Bithell, 1988)

General agreement has been met on the threshold for observing deterministic effects such as low birth weight, microcephally, overt mental retardation and other congenital malformations. This threshold for structural abnormalities is 100 miliSieverts (Metler, 1995). The occupational exposure limit allowed by federal regulation was set at $1/20^{th}$ this dose (10CFR20.1208). Thus 5 miliSieverts is the occupational exposure limit for expectant mothers during the entire pregnancy.

Besides structural abnormalities such as congenital malformations and low birth weight, ionizing radiation has been linked with childhood cancer and leukemia (Metler, 1994; Brent, 1983; Stewart, 1956; Mole, 1974) This effect is considered stochastic. This means that if just one photon of ionizing radiation strikes a cell nucleus at the right base pair, this single change could induce a full fledged case of childhood leukemia 5 to 10 years later.

The fact that general populations are exposed to natural background radiation from soil deposits and radon may well account for the natural incidence of childhood leukemia of 1:3000. Exposure to 5 miliSieverts of ionizing radiation, the occupational exposure limit for pregnant workers, is expected at the maximum of the confidence interval (RR = 1.4) to produce one excess case of childhood leukemia for every 4000 fetuses exposed (Metler, 1994). At the minimum of the confidence interval (RR = 0.8) the radiation exposure would be protective.

The question is then asked, "how much radiation are expectant aircrew members exposed to during routine operational tanker or transport flights?" Friedberg answered this question by actually monitoring radiation doses throughout dozens of domestic and transcontinental flights (Friedberg, 1989).

The usual flight at 40,000 ft altitude across areas south of 45 degrees north latitude gives an average dose of 0.005 miliSieverts. Routes north of 45 degrees north latitude can have doses ranging as high as 0.010 miliSieverts. Thus assuming a 10 month pregnancy, an aircrew member would need to fly 100 hours per month in southern

latitudes or 50 hours per month in northern latitudes in order to reach the occupational exposure limit of 5 miliSieverts over the ten months of pregnancy.

During normal operational tempo, the average crew member logs from 30 to 80 hours of flight per month. Rarely would all of these hours be logged in northern latitudes. It can therefore be concluded that expectant aircrew of tankers and transports should not be exceeding occupational exposure limits. One would therefore not expect to see an elevation of low birth weight or structural deformities arising from this occupational exposure.

SECTION 5: LOWBIRTH WEIGHT AND HYPOXIA

Hypoxia is another potential hazard in the flying environment (Scholten, 1976). There were few facts to base policy decisions on in the early 1970s regarding continued employment of expectant aircrew. Even today some countries continue to restrict women from aviation duty as soon a pregnancy is diagnosed (Andersen, 1990).

In 1976, Scholten cautioned that "the effects of working at cabin altitudes of 8,000 feet may have an adverse effect on reproduction." This opinion was based on an ecological comparison between the neonatal morbidity experience of villagers in Potosi, located at 13,700 feet in the Bolivian Andes and those living near sea level. Infertility, abortion, fetal and neonatal death are all much higher in Potosi.

Scholten also noted that the incidence of low birth weight was higher in Denver Colorado located at 5300 feet above sea level compared to rates reported in sea level cities. Both of these studies involved population based incidence rates and did not control for other confounding factors.

Follow-up case-comparison studies performed in Leadville, Colorado, could not find a correlation between hypoxia and low birth weight (Cotton, 1980). Currently there is no direct evidence linking the mild hypoxia experienced by flight crews at 8,000 ft cabin altitude to adverse reproductive outcomes (Lyons, 1993).

SECTION 6: THE STUDY PROPOSAL

The literature reviewed in connection with this thesis did not suggest a theoretical increase in the risk of low birth weight resulting from the amount of X-ray or hypoxia exposure encountered during tanker or transport flights while pregnant. A hypothesis was then formulated that Air Force women who work in tanker or transport aircraft should not demonstrate a higher incidence of low birth weight infants than Air Force office workers.

A cohort study comparing the incidence of low birth weight among offspring of Air Force aviators and officer workers was proposed to the Committee for the Protection of Human Subjects as part of this thesis. Permission to begin the study was granted by the Committee on February 21, 1997 (Appendix A).

The original study design proposed to link the occupational specialty code from the mother's record to birth weight data from the child's record. It was also proposed to control for smoking status, as smoking is a strong confounder. Controlling for race and age was also part of the proposal.

With a reported incidence in Magann's article of 5% low birth weight among the non-exposed, a sample size of 520 aviators was considered sufficient for a statistical power of 80% confidence in not rejecting the alternative hypothesis by chance (Schlesselman, 1974).

The problems encountered and the analysis that was actually performed are presented in the chapter that follows.

RESULTS

SECTION ONE: MATERIAL AND METHODS

A historical cohort of all inpatient birth events recorded in the Air Force Medical Support Agency (AFMSA) database of active duty women delivering babies in Air Force Military Airlift Command (MAC) and Strategic Airlift Command (SAC) Medical Treatment Facilities from January 1, 1980 to December 31 1994 was obtained and analyzed in the following manner.

STEP 1: PRIMARY SOURCE OF RECORDS. For years, AFMSA has maintained an electronic database of all discharge summary records for all admissions to military medical treatment facilities. From this database a spreadsheet was created including all discharge summaries of women admitted for pregnancy reasons from January 1,1974 to December 31, 1994.

Records were identified using surrogate identification numbers in place of military identification numbers to protect patient privacy. These surrogate numbers were included in the spreadsheet as the "RECORDID" column.

The records of infants of these women were selected using the same surrogate record identification system that was used for their mothers. Infants were selected based on an admission age of zero (birth) to 31 days. These records were then included in the spreadsheet. The final compiled spreadsheet, a secondary data set, contained 230,285 hospitalization discharge records. From hereon this data set will be referred to as the "Original Natality Data Set".

STEP 2: SECONDARY SOURCE OF DATA. Permission to obtain and use the Original Natality Data Set was requested and obtained by Dr. John Herbold, professor at the University of Texas Houston Health Science Center Public Health Program at San Antonio.

Permission to use the Original Natality Data Set as part of this thesis was requested by Thesis Proposal to the Committee for the Protection of Human Subjects. This committee granted permission on February 21, 1997 to use the Original Natality Data Set as proposed (Appendix A).

STEP 3: SELECTING THE COHORT. Since the purpose of the study was to compare reproductive outcomes of occupational cohorts and since the occupational cohort of primary interest was aviators, it was decided to confine the record search to Air Force Commands that that had the highest percentage of women aviators.

As discussed earlier, women began flying tanker transport and surveillance aircraft in 1976. It was not until 1993 that women began flying high performance combat aircraft. Prior to 1994, almost all women aviation positions were confined to two Air Force Major Commands (MAJCOMs): Military Airlift Command (MAC), due to the major grouping of transport aircraft, and Strategic Airlift Command (SAC), due to the major grouping of tanker aircraft supporting strategic bombers.

Records related to MAC and SAC were extracted from the Original Natality Data Set. Only records from Air Force military treatment facilities were searched.

Additionally, since very few women were on flying status during the 1970's, and since the International Classification of Diseases (ICD) codes changed from ICD-8 to ICD-9 in 1979, only records beginning with 1980 were searched.

Table 1, gives the count of records extracted from the Original Natality Data Set meeting the extraction criteria (1) MAJCOM =MAC or SAC, (2) facility =Air Force, (3) admission date =1980 to 1994.

Table 1. Number of Records in Each Data File.

Data File	RAW RECORDS
MAC ENLISTED 80-85	8827
MAC ENLISTED 86-94	10448
MAC OFFICER	2939
SAC ENLISTED 80-85	14410
SAC ENLISTED 86-89	9854
SAC ENLISTED 90-94	9401
SAC OFFICER	4009
Totals	59888

These 59,888 records were saved as seven Microsoft Excel 4.0 spreadsheet documents as shown in table 1. From hereon, this subset of the Original Natality Data Set will be referred to as the "Raw Data Set".

Each record in the Raw Data Set has 42 fields. The field titles and description of the data in the field is contained in Table 2 that follows on the next page.

Table 2. Description of Information in Each of 42 Fields Available for Each Record

Field #	Label	Description of field contents
1	SOURCE	Service type:1,2,3=Airforce,4,5,6=Army,7,8,9=Navy
2	GENERAT	Text A = adult, B = newborn, C = infant, X = unknown
3	STUDYID	Number: one per woman but common to all her babies
4	FPREFIX	Number: 20=mother,1=baby one, 2=baby two etc.
5	MTF	Text: the military treatment facility the record came from
6	ADM_YR	Number showing year of admission
7	ADM_MO	Number showing month of admission
8	ADM_DAY	Text showing day of admission
9	DISP_YR	Number showing year of discharge
10	DISP_MO	Number showing month of discharge
11	DISP_DAY	Text showing day of admission
12	BIRTHYR	Text showing year of admission
13	BIRTHMO	Text showing month of admission
14	BIRTHDAY	Text showing day of admission
15	ADM_AGE	Text showing age at admission
16	SEX	Text showing sex
17	RACE	Text showing race c = Caucasian, n = Black
18	OFF_ENL	Text showing E = enlisted, O = officer
19	MARITAL	Text showing marital status: M = married
20	PAYGRADE	Text showing paygrade:O1,O2,etc.
21	JOB_CODE	Text showing Alphanumeric code for job title AFSC
22	SERVICE	Text showing years of service
23	MAJCOM	Text showing Major Command e.g. MAC, SAC
24	DUTY_ZIP	Text showing zip code of sponsor
25	BENEFIT	Text showing beneficiary information
26	DIAG_IND	Number representing diagnostic series indicator
27	ICDDIAG1	Text showing first ICD code
28	ICDDIAG2	Text showing second ICD code
29	ICDDIAG3	Text showing third ICD code
30	CAUSEDTH	Text showing underlying cause of death
31	DTHPOINT	Text: death pointer O = no death 1=1st ICD,2=2nd ICD, etc.
32	P_FETUS1	Text fetus 1 presentation, 1*=live,2*=dead (mom's record)
33	P_FETUS2	Text: fetus 2 presentation, 1*=live,2*=dead (mom's record)
34	SICKDAYS	Number showing total sick days in military career
35	BEDDAYS	Number showing sick days related to this hospitalization
36	DISPTYPE	Text:disposition:30=died in hospital, 41=DOA,42=died ER
37	DISPSERV	Text showing medical follow up, ACB =Ob, AD(A-D)=Peds,
38	REC_TYPE	Number representing 1= this record is a hospital record
39	RECORDID	Number: unique record ID, one number per record
40	KEEPER	Number 0=keep this record,1=delete

Each of the seven files from the Raw Data Set was saved as new Excel 7.0 files. The Excel files were then imported file by file into an Access 7.0 database for data manipulation.

STEP 4: DATA PREPARATION. The field formats were changed from text to number in the three admission date fields, the three disposition date fields, the three birth date fields and the age field.

STEP 5: CHECK DATES. The admission and discharge fields were sorted by ascending values and inspected manually for numerical values less than one. All records had acceptable discharge date values by this method. Some records were missing admission dates. For records missing an admission date, the admission date was corrected by taking the same records discharge date and subtracting the hospital days.

STEP 6: SEPARATE MOTHERS FROM NEWBORNS. The mother, newborn and infant records were then extracted into separate tables using generation codes "A", "B" or "C". The birthday fields for infants and newborns were then sorted by ascending values and inspected for values less than one.

All newborn records had acceptable birthday values. Table 3 shows the count of records selected from the Raw Data Set and divided into mother, newborn and infant tables with an adjoining column showing the number of records requiring correction.

Table 3. Count of Mother, Newborn and Infant Records in Each of the Data Files.

File	RAW RECORDS	MOMS	A	NEWBORNS	B	INFANTS	C
MAC ENLISTED 80-85	8827	5751	0	3020	0	56	0
MAC ENLISTED 86-94	10448	6462	1	3910	0	76	23
MAC OFFICER	2939	1713	0	1201	0	25	5
SAC ENLISTED 80-85	14410	9245	0	5081	0	83	0
SAC ENLISTED 86-89	9854	6605	33	3174	0	75	54
SAC ENLISTED 90-94	9401	5747	5	3552	0	102	0
SAC OFFICER	4009	2355	2	1620	0	34	6
Totals	59888	37878	41	21558	0	451	108

Column A =count of MOMS records needing corrections (admission dates)
Column B =count of NEWBORN records needing corrections (birth dates)
Column C =count of INFANT records needing correction (birth dates)

STEP 7: THREE DATE FIELDS TO ONE DECIMAL. The admission year, month and day fields were then used to calculate a single decimal type admission date. To do this, a table was created which related the birth month to the cumulative number of days in the year up to the beginning of the birth month. All years were treated as leap years, since this decimal was used simply for record comparison purposes and not for tabular output data. Table 4 shows the relationship.

Table 4 Number of Days from January 1 to the Beginning of the Birth Month

Month number	Number or days in current month	Cumulative days to beginning of current month
1	31	0
2	29	31
3	31	60
4	30	91
5	31	121
6	30	152
7	31	182
8	31	213
9	30	244
10	31	274
11	30	305
12	31	335

Using the above table, the following logic was used to compute the decimal fraction of the year represented by the admission month and day. First the number in the cumulative days was substituted for the admission month. This value will be called CMD for cumulative month days. Second, the admission day (AD) was added to the cumulative days number to give the total number of days since the beginning of the admission year. This sum was divided by 377 to provide a decimal representation of the total number of days in the year with the number still representing the index year. If 366 is used the decimals computed for babies born on December 31 of 1989, the decimal becomes 1990.00000. Using 377 gives a decimal of 1989.9998.

This decimal fraction was added to the year to give the final decimal. This logic is summarized in the following equation. DECIMAL = YEAR+((CMD+AD)/377). The above logic was used to compute decimal discharge and birth dates for all records.

STEP 8: ASSIGN RESEARCH CATEGORY. A table was created with Air Force job codes in one field and research categories in an adjoining field. An index of job titles for each job code was obtained from Armstrong Laboratory at Brooks Air Force Base. Categorization methodologies were consistent from 1980 to 1992. After 1992, a new job classification system was introduced. A cross reference table was obtained from the Personnel Flight at Lackland Air Force Base.

Using this data, job codes were inspected line by line and assigned a research category number. The assigned categories were, one for aviator, two for medical, three for industrial shop, four for administrative office and five for job title unknown. A table of the Air Force job numbers and the research category that was assigned to each job number is included as the Appendix B for enlisted personnel and Appendix C for officer personnel codes.

STEP 9: MATCH MOTHER TO NEWBORN. Duplicate records were searched for and eliminated bring the total records available from 59,888 to 59,880. Newborn records were then matched to mother records. To do this, records were selected that had the same study ID. The newborn record birth decimal was then compared to the mothers admission and discharge decimals.

If the admission decimal was less than or equal to the birth decimal, and the discharge decimal was greater than or equal to the birth decimal, then the match was made. Unfortunately, a good number of women were discharged from the hospital and

then readmitted for delivery the same day. Duplication of the newborn records were searched for and the record with the latest admission date was retained.

STEP 10: FIND TWINS. Duplications of the mothers record also happened due to twins and higher multiple gestational deliveries. To eliminate these duplications, a list of twins was created. Twins with Family Prefix numbers of one were selected from this file as twin number one. Twins with family Prefix of two were then selected and the twin belonging to twin one was added to twin one's record. Twin two's record was then deleted. The remaining twins with family Prefix number of two were then designated as twin one and the same logic was repeated until all the twins were removed.

STEP 11: FIND TRIPLETS. Triplets were eliminated by first searching newborns with family prefix number three for matches with newborns with a family prefix number one, following the same logic used for twins. Once all the duplicates were eliminated, there were 18,588 birth events available for analysis.

STEP 12: FIND LONE TWINS. The birth events table, minus the twins and triplets found by the duplicate record search, was then examined for mother's records that were designated with ICD codes V272 through V277 or V2720 through V2770. These codes represented all types of multigestational deliveries. Birth events meeting these criteria were designated lone twins. Sixty one events of a single live born twin were documented in this fashion.

The number of birth events categorized as single, twins both live, twins only one alive at birth, or triplet is summarized in Table 5.

Table 5. Number of Records Matched as Birth Events.

Type of Birth Event	Count of Records
PURE SINGLETON BIRTHEVENTS	18588
TWINS BOTH LIVE BIRTHEVENTS	102
TRIPLET BIRTH EVENTS	1
TWINS ONLY ONE ALIVE AT BIRTH	61
TOTAL BIRTHEVENTS	18752

STEP 13. CHECK NON-MATCHES. The residual newborn records (those newborn records still not matched to a mother's record) were then searched to see how many records had a corresponding mother's record with the same study identifier. This search revealed about 60% of the residual newborn records did not have a study ID which corresponded to a mother's study ID. Therefore, this subset of the residual newborn records was eliminated from the study population.

The other 40% of the residual newborn records did have a corresponding mother's record. However, the mother's admission dates were inconsistent with the newborn's birth date. Since the mother can change jobs, and since the job is reported on the mother's admission record, and since the mother's admission was not related in time to this second subset of residual newborn records, and since the purpose of the study was to evaluate the effects of occupational exposures during pregnancy, it was decided to eliminate this second and last subset of residual newborns from the study population also in order to assure greater reliability of exposure according to job title.

STEP 14: MERGE FILES. At this point the officer and enlisted files were inspected for accurate identification as officers vs. enlisted and then merged. Following the merge, both the MAC and the SAC tables were inspected for duplicates, and duplicates were eliminated.

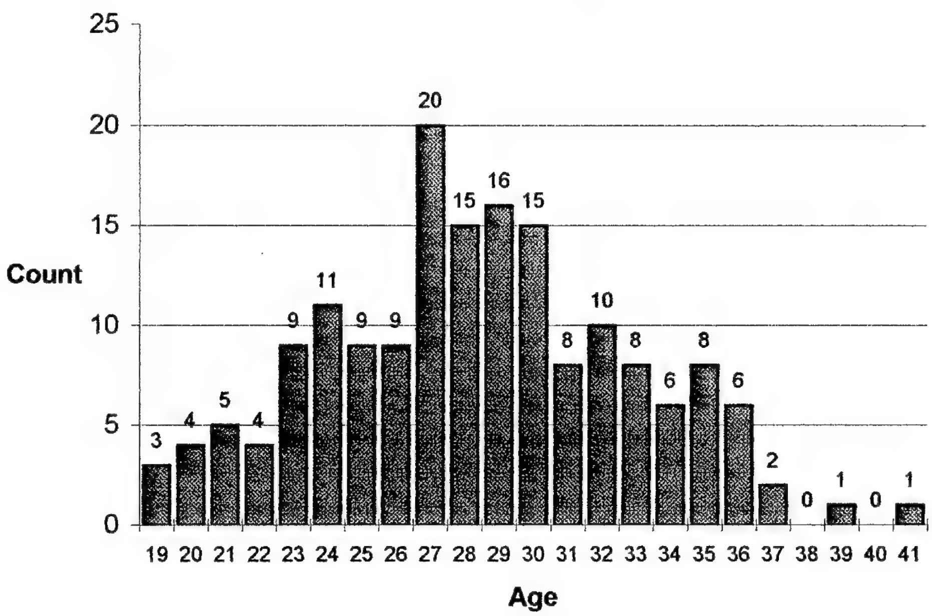
This action left the final population at risk at 18,730. The population at risk was defined as the birth events recorded in the Raw Data Set which occurred in Military Airlift Command and Strategic Airlift Command between January 1, 1980 and December 31, 1994 in which the mother's hospitalization overlapped with the recorded birthday of the newborn.

SECTION TWO: DEMOGRAPHICS

From this population of 18,730 Air Force women, 170 were aviators. In this section demographic features of this aviator cohort will be displayed. The next section will compare the aviator cohort to the administrative office workers.

Figure 1 displays the age of all aviator mothers at the time of their delivery. The range was from age 19 to 41. The average age was age 28; the median was age 30, and the mode was age 27.

Figure 1. Age at delivery of all 170 MAC and SAC Aviators from 1980 to 1994



In figure 2, the officers are compared to the enlisted. The officers are on top and the enlisted are on the bottom. This figure demonstrates that the enlisted began delivering at younger ages than the officers, and that they stopped having children at younger ages.

The age range for enlisted deliveries was 19 to 36. The average was 26; the median was 26 and the two modes were 23 and 28.

For officers the age range was 23 to 41. The average was 30; the median was 30, and the mode was 27.

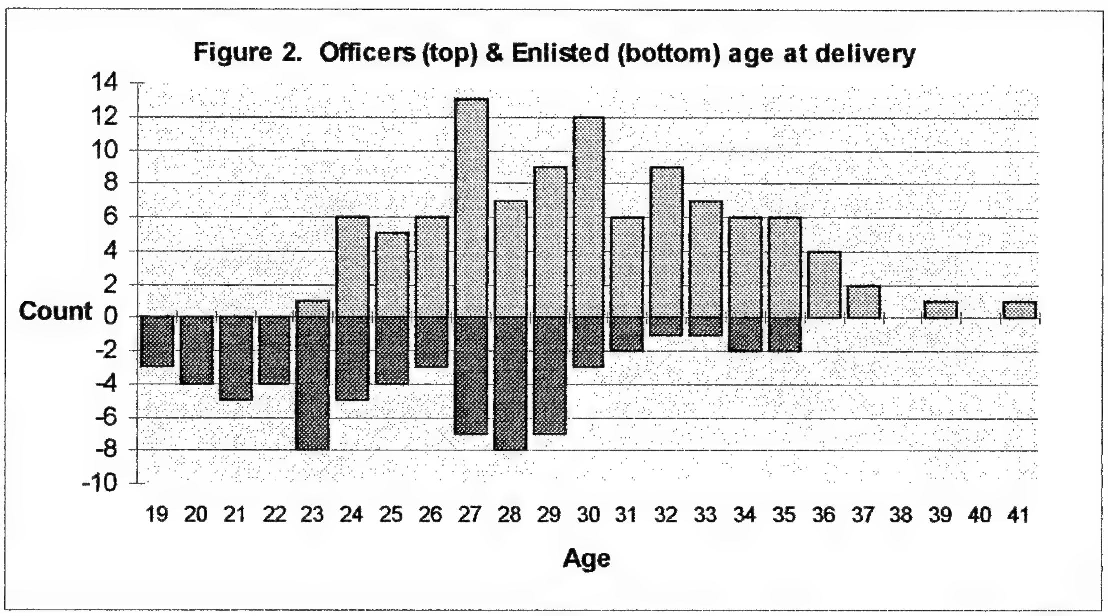


Figure 3 displays the count of deliveries in each calendar year. There were very few deliveries in the early eighties. As confidence grew, that careers were not threatened by pregnancy, the numbers began to increase.

The peak number of deliveries occurred during the Gulf War years. This may have been due to happy reunions after long deployments, or trading the risk of pregnancy for the risk of war.

Figure 3. Year of Delivery of 170 Air Force Aviators

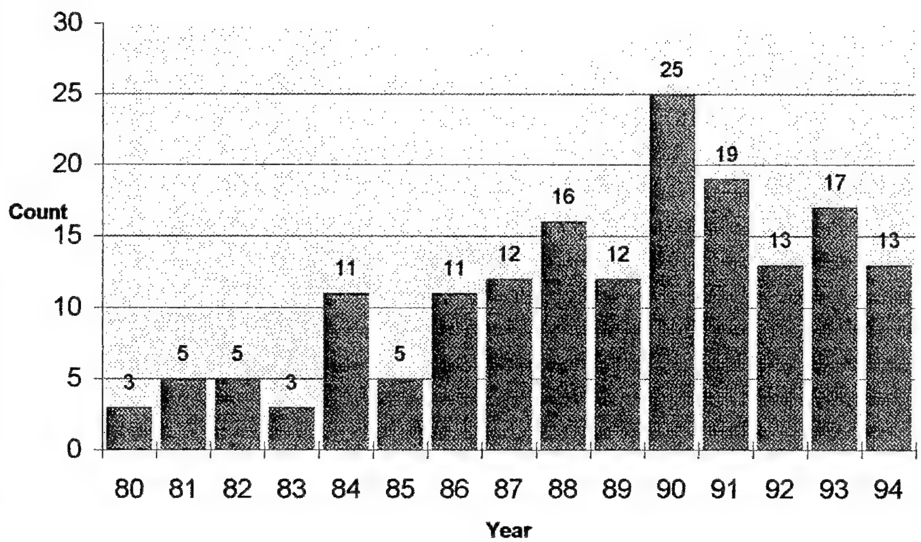
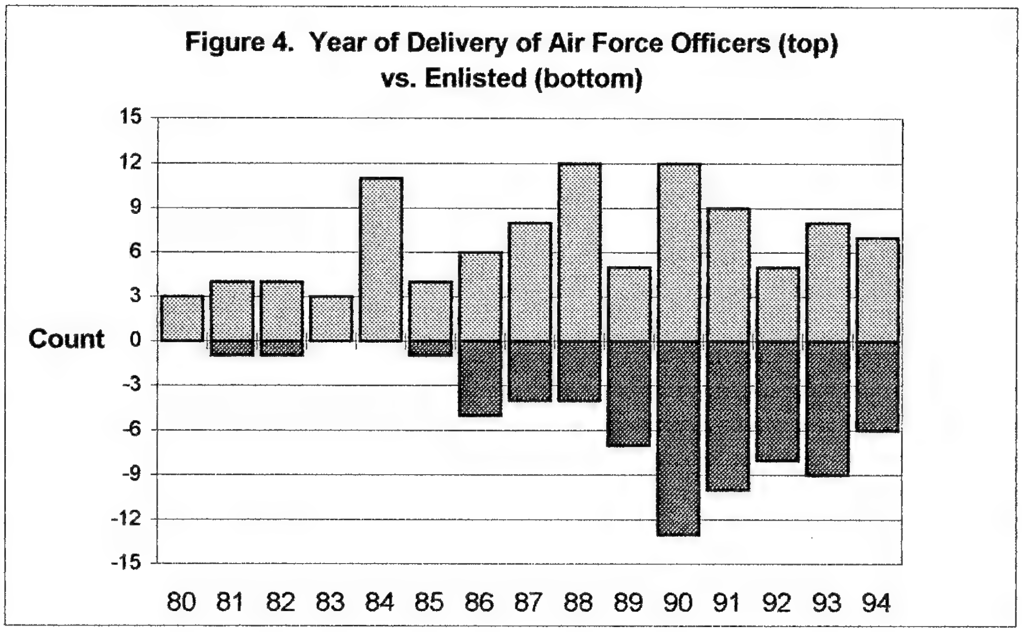


Figure 4 displays the calendar year of delivery. The officers are above the X axis and the enlisted below the X axis. This figure shows enlisted personnel only delivered two babies from 1980 to 1984. In contrast, officers delivered 24. After 1984 the delivery rates were almost equal.



Figures 5 displays the ethnic distribution among the officers that delivered.

Figure 5. Ethnic Make-up of Delivering Officers

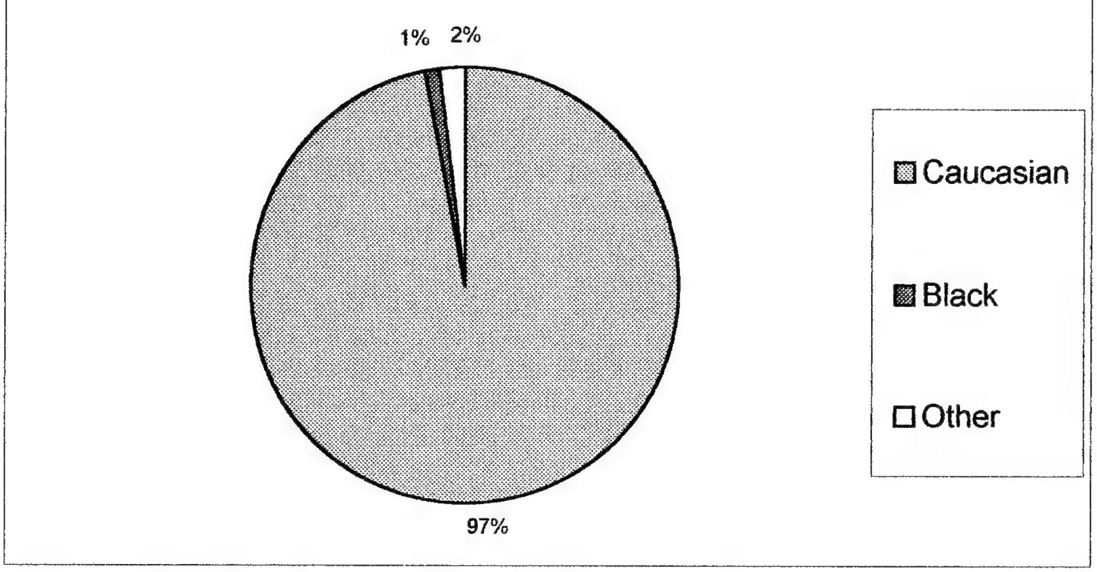


Figure 6 shows the ethnic distribution of the enlisted aviators who delivered.

Figure 6. Ethnic Make-up of Delivering Enlisted Aviators

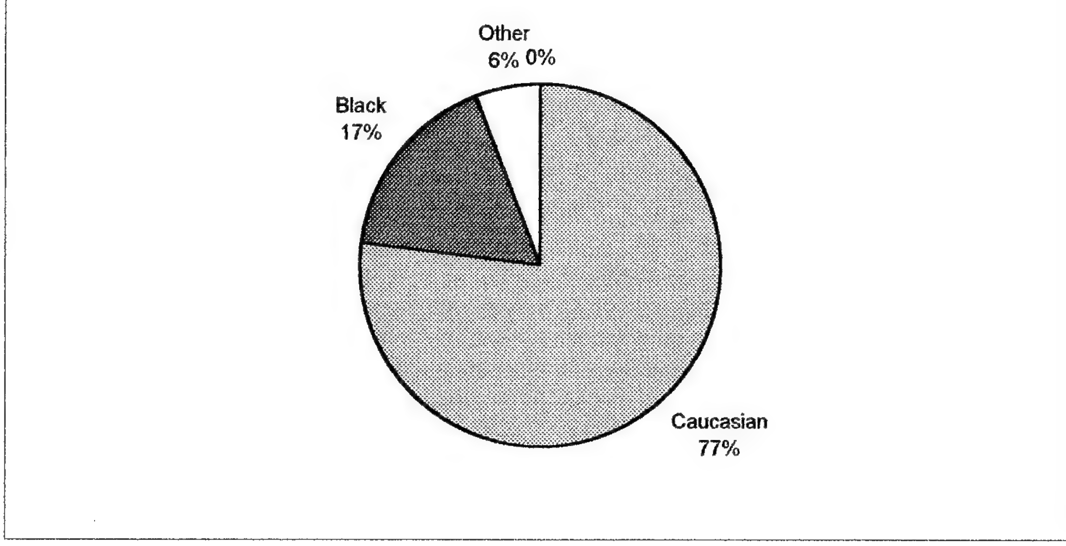


Table 6 displays the frequency that diagnoses were encountered among the 170 deliveries of aviators. The most frequent diagnosis was neonatal jaundice. This occurred 13 times giving an incidence of 7.6% compared to 11.8 % for office workers.

Table 6. The Frequency of ICD-9 Diagnoses among the 170 offspring of aviators.

MAC and SAC 1980-1994		
ICD DIAGNOSIS	COUNT	DIAGNOSIS
774	13	JAUNDICE
766	12	HEAVY OR POST TERM
767	10	BIRTH TRAUMA
757.33	6	SKIN ANOMALY UNSPECIFIED
770	4	NEWBORN RESPIRATORY DISTRESS
773	4	ISOIMMUNIAZATION
603.9	2	HYDROCELE
754	2	MUSKULOSKELETAL DEFORMITY
768	2	FETAL DISTRESS
768.6	2	BIRTH ASPHYXIA
785.2	2	HEART MURMUR
38	1	SEPTICEMIA, STREP
228.09	1	HEMANGIOMA
276.1	1	HYPONATREMIA
427.9	1	CARDIAC DYSRRHYTHMIA
695	1	DERMAL ERYTHEMA
709.9	1	SKIN, UNSPECIFIED
743.65	1	CONGENITAL EYELID ANOMALY
743.8	1	CONGENITAL ANOMALY OF THE EYE
752.6	1	HYPOSPADIA
755.1	1	SYNDACTILY
755.3	1	CONGENITAL REDUCTION OF LOWER LIMB
764.09	1	LIGHT FOR DATES
765.19	1	PRETERM
772.8	1	FETAL HEMORRHAGE
910	1	SCALP INJURY
V053	1	CORRECTIVE DEVICE
V502	1	CIRCUMCISION

The second most common condition found was birth trauma. Birth trauma occurs as a result of obstetrical manipulation and should not be influenced by the occupation of the mother. For this reason, comparison of risk between the occupational groups was not performed for this diagnosis.

Code 770, newborn respiratory distress occurred 4 out of 170 times in the aviators for an incidence of 2.3%. This compares favorably to 3% for the office workers. Other variables became too small to make useful comparisons.

Provided that hospital records continue to be entered into the data base at Armstrong Laboratory, future comparisons of these other diagnosis will be useful as soon as sample sizes are large enough.

SECTION THREE: COMPARING BIRTHWEIGHTS OF AVIATOR'S OFFSPRING VS. ADMINISTRATIVE OFFICE WORKER'S OFFSPRING

STEP 1: SELECT CASES. The selection of cases was a difficult process. In the study design, it had been proposed to look at the newborns birth weight. A case was to have been defined as a birth weight less than 2500 grams.

Because the Original Data Set did not contain actual birth weight data, a surrogate was looked for in the International Classification of Diseases(ICD) codes in fields 27, 28, and 29. The ICD codes of 764 and 765 contain the diagnoses of "light for dates" and "growth retardation and premature" respectively. A count of the number of newborns with the ICD diagnosis of 764 and 765 with any character in the fourth or fifth digital space is displayed in Table 7.

Table 7. Cases of ICD diagnosis 764 or 765

Status	Flyer	Medical	Shop	Office	Unknown	Total
Enlisted cases	2	57	64	246	34	403
Enlisted non-cases	67	2014	3136	10236	736	16189
Percent Enlisted cases	2.9%	2.8%	2.0%	2.3%	4.4%	2.4%
Officer cases	0	29	1	17	1	48
Officer non-cases	101	1000	119	753	117	2090
Percent officer cases	0.0%	2.8%	0.8%	2.2%	0.8%	2.2%
Total cases	2	86	65	263	35	451
Total non-cases	168	3014	3255	10989	853	18279
Percent total cases	1.2%	2.8%	2.0%	2.3%	3.9%	2.4%

Step 2: ELIMINATE PRETERM BIRTHS. The study design called for term low birth weight; therefore, the diagnosis of 765 which is specific for premature deliveries needed to be excluded. Table 8 shows the number of cases derived from the

cohort of 18730 deliveries in which the newborn had the code 764 as one of the three diagnosis encoded.

Table 8. Cases of code 764 light for dates excluding premature code 765.

Status	Flyer	Medical	Shop	Office	Unknown	Total
Enlisted cases	1	10	8	50	11	80
Enlisted non-cases	68	2061	3192	10432	759	16512
Percent enlisted cases	1.45%	0.48%	0.25%	0.48%	1.43%	0.48%
Officer cases	0	3	0	4	0	7
Officer non-cases	101	1026	120	766	118	2131
Percent Officer cases	0.00%	0.29%	0.00%	0.52%	0.00%	0.33%
Total cases	1	13	8	54	11	87
Total non-cases	169	3087	3312	11198	877	18643
Total Percent	0.59%	0.42%	0.24%	0.48%	1.24%	0.46%

STEP 3: CONTROL FOR AGE. To control for age as a confounding variable, the data were searched again using only birth events in which the reported age of the mother fell between age 25 and 34. This would eliminate problems inherent with deliveries at the younger or older ages. The results are displayed in Table 9.

Table 9. Cases of ICD Diagnosis 764 from Deliveries of Mothers Ages 25-34.

Status	Flyer	Medical	Shop	Office	Unknown	Total
CASES	1	7	4	24	5	41
NON-CASES	115	1616	1301	4776	381	8189
TOTAL	116	1623	1305	4800	386	8230
PERCENT	0.86%	0.43%	0.31%	0.50%	1.30%	0.50%

STEP 4: CONTROL FOR RACE. This process was repeated using ages 25-34 again and at the same time selecting only Caucasians. The results are displayed in table 10.

Table 10 Cases of ICD Code 764 Among Caucasians Ages 25-34.

Status	Flyer	Medical	Shop	Office	Unknown	Total
Cases	1	6	4	11	3	25
Non-cases	101	1299	1139	3388	307	6234
Total	102	1305	1143	3399	310	6259
Percent	0.98%	0.46%	0.35%	0.32%		0.40%
Relative Risk*	3.06	1.43	1.09	1		
P-value (Fisher's exact)	0.299	0.324	0.545			
Upper 95% Confidence Limit**	24	3.87	3.43			
Lower 95% Confidence Limit**	0.4	0.53	0.35			
*Relative to office workers						
**Confidence limits by method on p170 of Basic & Clinical Biostatistics (Dawson-Saunders, 1994)						

Medical workers and shop workers were compared against office workers to ascertain if other exposure categories might be contributing to increased risk.

According to this data, there is an elevated risk for all three categories compared to office workers: 3.06 for aviators, 1.43 for medical workers, and 1.09 for shop workers. However, using the Fisher's exact test, the p-value was larger than 0.05 for all three categories and the 95% confidence interval for the relative risk straddled unity in all three categories.

The Chi-square was considered for computation of a p-value, but the number of expected cases in the Flyer, Medical and Shop columns were less than 5. When a cell contains expected cases of less than 5, the Chi-square test is no longer valid. Therefore, the Fisher's exact test was used to compute the p values. Despite using the more exact test, none of the p-values were significant.

The amount of power available with a sample of 102 aviators and an expected incidence of only 0.0032 is very low. Using Schlesselmen's, formula for a cohort study,

and setting a desired alpha of 0.05, and the incidence at 0.32%, the following table of sample sizes would be needed to gain a power of 70%, 80%, and 90% respectively (Schleselman, 1974).

Table 11. Calculations of Power Based on Alpha =0.05 and a Relative Risk of 1.9%

Incidence	Relative Risk	Alpha	Beta	Power	Sample size
0.32%	1.9	0.05	0.1	90%	11688
0.32%	1.9	0.05	0.2	80%	8730
0.32%	1.9	0.05	0.3	70%	6849

The only conclusion then from this investigation is that the sample size turned out to be too small to reach statistical significance.

Future low birth weight cohort studies will need at least 7,000 aviators and preferably 11,000 aviators before a solid statistical conclusion for or against the null hypothesis can be made. If a case-comparison study were chosen instead of a cohort study, the sample size needed would still be very large. Aviators represent only 0.9% of the women exposed to active duty. With an odds ratio of 1.3, and using the Epi Info software program, it was calculated that 11,381 cases would be required to obtain 95% alpha and 80% power using 5 comparisons for every case.

Because smoking has already been associated with low birth weight, future studies should seek a means of controlling this possible confounder.

DISCUSSION

The purpose of this thesis was to look back to find if there is reason either from the literature or from the actual natality experience of Air Force aviators to believe that the current policy of allowing women to fly tankers and transports while pregnant poses a health risk to the mother or fetus.

The large body of evidence concerning ionizing radiation confirms the relative safety of very low doses of ionizing radiation at 40,000 feet of altitude. Aircrew flying less than 50 hours per month are exposed to levels below the occupational level of 5 miliSieverts per pregnancy set by the Code of Federal Regulations 10CFR 20.1208.

Between 50 and 100 hours of flying a month might exceed the standard if the flight path is in extreme northern latitudes. Flying more than 100 hours a month will probably cause exposure to expectant mothers higher than OSHA standards.

The mild relative hypoxia encountered at typical cabin pressure of 8,000 feet has not been associated with adverse neonatal outcomes.

To date, the bulk of the natality experience of the Air force resides in the former Military Airlift Command (MAC) and the former Strategic Airlift Command (SAC). Of the 170 deliveries of MAC and SAC aviators, only one case of term low birth weight was identified. This produced a rate of 0.9% among the 102 Caucasian aviators ages 25-34. Relative to the 0.32% rate of the office workers of the same age and race, the risk was tripled. However, with a Fisher's exact p-value of 0.299, and a confidence

interval of 0.4 to 24, this rate was not statistically different than the 0.32% incidence among office workers due to lack of power.

Limitations in the study were the unavailability of birth weight, gestational age at birth, mother's smoking history, actual flight time logged while pregnant, and the small number of deliveries.

Future studies should aim at acquiring accurate smoking histories, stress correlation, detailed flight logs, date of last menstrual period, birth weight data, and a sufficient sample size. According to the sample size calculation of Schlesselman for cohort studies, in order to have an 80% assurance of not committing a type II error of not rejecting the alternative hypothesis when in fact the alternative hypothesis is closer to the truth, the sample size will need to be at least 8730 aviators (Schlesselman, 1974).

This size of sample will not be available for many years. Pooling data from stewardesses from the United States and abroad could help reach the sample size needed. Until then, the question remains only partially answered.

APPENDIX A: Copy of Permission to Utilize Data Granted by the Committee for the Protection of Human Subjects.

APPENDIX B: Enlisted Job Code to Research Category (R-ID) Conversion Chart

R-ID	JOB	R-ID	JOB	R-ID	JOB	R-ID	JOB	R-ID	JOB	R-ID	JOB
5	???	4	205	4	291	3	404	4	521	3	634
5	000	4	206	4	293	3	405	4	527	3	635
5	001	4	207	4	294	3	411	4	531	4	641
5	003	4	208	4	295	3	421	4	538	4	642
5	004	4	209	4	296	3	422	4	541	4	644
5	005	4	215	4	297	3	423	3	542	4	645
5	006	4	219	3	301	3	424	3	543	4	647
5	021	4	221	3	302	3	425	3	544	4	649
5	090	4	222	3	303	3	426	3	545	4	651
5	092	4	223	3	304	3	427	3	546	4	652
5	093	4	224	3	305	3	430	3	547	4	653
4	100	4	231	3	306	3	431	3	548	4	654
1	103	4	232	3	307	3	432	3	551	4	655
1	106	4	233	3	308	3	433	3	552	4	660
1	111	4	234	3	309	3	436	3	553	4	661
1	112	4	239	3	312	3	443	4	554	4	662
1	113	4	241	3	316	3	445	4	555	4	671
1	114	4	242	3	317	3	451	4	559	4	672
1	115	4	250	3	320	3	452	3	566	4	673
1	116	4	251	3	321	3	453	4	571	4	674
1	117	4	252	3	322	3	454	4	573	4	675
1	118	4	253	3	323	3	455	4	574	4	691
4	121	4	254	3	324	3	456	4	582	4	700
4	122	4	257	3	325	3	458	4	587	4	701
4	123	4	262	3	326	3	461	4	591	4	702
4	132	4	263	3	328	3	462	4	601	4	703
4	141	4	264	3	329	3	463	4	602	4	704
4	145	4	265	3	341	3	464	4	603	4	705
4	150	4	267	3	342	3	465	4	604	4	707
4	155	4	271	3	343	3	469	4	605	4	709
4	158	4	272	3	360	3	472	4	611	4	711
4	161	4	273	3	361	3	475	4	612	4	713
4	163	4	274	3	362	4	491	4	615	4	715
4	171	4	275	3	363	4	492	4	621	4	721
4	174	4	276	3	390	4	493	4	622	4	722
4	182	4	277	3	391	4	494	4	623	4	723
4	201	4	281	3	392	4	496	4	624	4	731

4	202	4	282	3	401	4	503	4	625	4	732
4	203	4	283	3	402	4	509	4	627	4	733
4	204	4	288	3	403	4	511	3	631	4	734

Enlisted Job Code to Research Category (R-ID) Conversion Chart Continued.

R-ID	JOB	R-ID	JOB	R-ID	JOB	R-ID	JOB	R-ID	JOB		
4	735	2	914	4	991	4	3S2	5	43H		
4	736	4	915	4	992	4	4A0	4	319		
4	737	4	916	4	995	4	4A1	3	2T4		
4	741	3	918	4	996	3	4A2	5	096		
4	742	3	919	4	997	3	4B0				
4	745	2	921	4	999	2	4F0				
4	751	2	922	5	-9	2	4H0				
4	752	2	923	1	1A0	2	4M0				
3	753	2	924	1	1A1	2	4N0				
4	791	2	925	1	1A4	2	4N1				
4	792	2	926	4	1C1	2	4P0				
4	796	2	927	4	1C3	2	4R0				
4	801	2	928	4	1N2	2	4T0				
4	802	2	931	4	1N3	2	4Y0				
4	804	2	932	4	1N4	4	5J0				
4	811	2	935	3	2A0	4	6C0				
4	812	2	936	3	2A1	4	6F0				
4	813	2	941	3	2A4	3	917				
4	815	2	942	5	43D	5	9P0				
4	821	2	950	3	2A5	5	47G				
4	822	2	951	3	2A6	5	43D				
4	823	2	952	3	2E0	5	13B				
4	851	2	955	3	2E1	5	36P				
4	871	2	959	4	2E7	5	44Z				
4	872	2	962	4	2S0	5	93P				
4	881	2	963	4	2T0	5	14N				
4	882	2	968	4	2T1	5	36P				
4	892	2	971	4	2T2	5	35B				
2	901	2	972	3	2T3	5	12A				
2	902	2	973	3	2W0	5	008				
2	903	2	975	4	3A0	5	24T				
2	904	2	976	4	3C0	2	4E0				
2	905	2	980	4	3C1	4	285				
4	906	2	981	4	3C2	5	23S				
4	907	2	982	4	3C3	4	8T0				
2	908	2	983	4	3E0	5	21A				
2	909	2	985	4	3N0	5	31P				
2	911	2	987	4	3P0	4	9A2				

2	912	2	988	4	3S0	4	2R1				
2	913	4	990	4	3S1	5	007				

APPENDIX C: Officer Job Code to Research Category (R-ID) Conversion Chart.

R-ID	JOB	R-ID	JOB	R-ID	JOB	R-ID	JOB	R-ID	JOB
4	182	4	289	3	513	4	732	2	927
4	183	3	2A3	3	515	4	734	2	928
4	189	4	301	3	516	4	736	2	929
4	192	4	302	4	51J	4	737	2	931
1	1A0	4	303	3	551	4	741	2	932
1	1A1	4	304	3	552	4	742	2	934
4	201	4	305	3	554	4	751	1	935
4	202	4	307	3	571	4	752	2	936
4	203	4	311	3	573	4	791	2	938
4	204	3	312	3	591	4	792	2	939
4	205	4	316	4	601	4	801	5	93P
1	206	4	321	4	603	4	802	2	941
1	207	4	33S	4	605	4	803	2	944
3	21A	4	341	4	611	4	804	2	949
1	222	4	3S0	4	612	4	805	2	952
1	226	4	401	4	621	4	807	2	955
4	231	3	402	4	622	4	808	2	956
4	232	3	405	4	623	4	811	2	957
4	235	3	411	4	624	4	812	2	958
4	23S	5	423	4	641	4	819	2	963
4	251	5	424	4	642	4	822	2	965
4	252	2	42B	4	643	4	871	5	96U
4	253	4	431	4	645	4	881	2	971
4	254	2	43D	4	651	4	882	2	972
4	258	2	44K	4	653	4	892	2	973
4	261	2	44P	4	661	4	901	2	974
4	262	5	451	4	662	4	902	2	975
4	263	2	46A	4	671	4	906	1	976
3	264	1	46F	4	672	4	907	2	977
4	267	2	46M	4	673	3	912	2	978
4	268	2	46N	4	674	3	914	2	981
4	271	2	46S	4	675	3	915	2	982
4	272	4	491	4	678	3	916	2	985
4	275	4	492	4	691	3	917	2	986
4	276	4	493	4	692	2	918	2	987
4	281	4	494	4	701	2	919	2	988
4	282	4	495	4	702	2	921	2	990
4	283	4	499	4	703	2	922	2	993
4	284	4	4A0	4	704	2	923	2	995

4	285	2	4N1	4	720	4	924	2	999
1	286	3	512	4	731	2	925	5	9P0

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VITA

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